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ABSTRACT

Previous studies have shown that where bilinguals have a poorer grasp of some language than monolingual speakers of that language, the deficit has almost invariably revealed itself in reading skill. Also, the deficit in language is usally associated with a relatively lower mean IQ for bilinguals when tested orally. Bilinguals have also been found weaker than monolinguals in problem arithmetic, but not in mechanical arithmetic. The author does not imply that bilingualism is necessarily connected with a language or intellectual deficit; he attempts, rather, to explain such deficits when they occur. In his studies of reading speed and problem solving in English and Irish, carried out with fifth and sixth grade children in Dublin and Dundalk primary schools, significant differences between languages were found in the speed at which subjects interpreted the meaning of individual words and sentences, in the speed at which subjects could pronounce words, and in ability to anticipate the sequence of words in continous prose. The implications concerning these differences for bilingual students are discussed. (AMM)

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COMPARATIVE STUDIES OF READING AND PROBLEM SOLVING IN TWO LANGUAGES

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From studies of bilingual persons come a series of results which relate linguistic and non-linguistic functioning. Where bilinguals have been found to have a poorer grasp of some language than monolingual speakers of that language the deficit has almost invariably revealed itself among other things in reading skill.[1] Additionally, the deficit in language is usually associated with a relatively lower mean IQ for bilinguals when the test is a verbal one, but not when it is a non-verbal one.[2] In a number of studies, too, bilinguals have been found weaker than monolinguals in problem arithmetic, but not in mechanical arithmetic.[3] These are hardly surprising conclusions and my main interest here is not in establishing them or in discussing the evidence on which they are based, but rather to inquire about possible reasons why they might be true. Nothing I say, however, should be taken as implying that bilingualism is necessarily connected with a language or intellectual deficit; I am merely attempting to explain such deficits when they occur.

Some explanations of reading and problem-solving difficulties in bilinguals are so immediate that they need not detain us. Obviously if I were set a problem in Russiam, a language of which unfortunately I do not know a word, I would not be able to solve it no matter how simple it was. It is equally obvious that if I were set a problem in Italian, a language which I can usually decipher with some difficulty, I could well be tripped up by some words or idiomatic turns of phrase which were incomprehensible to me. In the present paper I wish to abstract from such very real linguistic difficulties and to ask what happens when I set a problem in a language that I can read tolerably well, such as Irish or French,

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but which nevertheless is not my native language. In effect, I am asking whether there is such a thing as command or grasp of language which enables me to read English with greater ease and mastery than I read Irish or French. Further, if the answer to that question is yes, I wish to inquire in what such mastery might consist. In attempting to answer these questions I shall draw on several studies which I and my colleagues have conducted over the years both in Dublin and Montreal, but which I have not hitherto drawn together in a single article.

Problem solving in two languages

The first two investigations[4] approached the problem in a global manner. The central part of the plan was to select persons who knew two languages, but not both equally well, set them problems in the two languages, and make sure that they understood every word and expression used in the problems. The persons we selected were all native speakers of English and all had studied Irish for at least six years. They were sixth grade children, boys and girls, in certain Dublin and Dundalk primary schools. In the first study the number of children was 62; in the second it was 341. The problems were either specially composed or "borrowed" for the purpose. The crucial thing was that though the problems involved relatively complex reasoning processes they could be expressed in both languages in terms that would be familiar to the children. To ensure that the children understood the language in which they were expressed, a series of simple problems was devised which made use of the same vocabulary and syntactic structures as were used in the complex problems. An example of a problem in complex form is:

> If May is the sixth month of the year and if a pound is not more than an ounce divide 81 by 9. Otherwise subtract 3 from 7. Write down your answer.

The set of simple problems into which this was broken in order to test children's understanding of each of its components is:

(a) May is the sixth month of the year	Right	Wrong	I don't know
(b) A pound is more than an ounce.	Right	Wrong	I don't know
(c) Divide 81 by 9	Answer		
(d) Subtract 3 from 7	Answer		
(e) If a crow is white write 8, otherwise write 9.	Answer		

The last item was included to test understanding of the "if - otherwise" construction. Each complex problem and its associated simple problems were expressed in Irish and in English. In each school which took part in the study the sixth grade pupils were divided at random into groups of equal sizes, one group in each to answer the Irish problems, one to answer the English ones.

The results were analysed separately for each problem. Only the responses of those children who had answered all the simple questions associated with a particular complex problem were analysed. The purpose was to determine whether among those who understood the language a significantly larger proportion of "English" children than of "Irish" ones solved the complex problems. A chi-square test yielded the answer "yes" in the case of about half the problems. So far we have been unable to determine the distinguishing characteristics of the problems which yielded positive results. But the overall outcome is clear: differential levels of "grasp of language" were established by the children's responses to the complex problems.

Reading speed in each language

What precisely is the nature of the difficulty indicated in the problem-solving studies just described? Where in the various processes of assimilating and dealing with the information did it occur? A first clue came from an earlier study[5] in which it was found that fifth and sixth grade children solved problems equally accurately in their two langauges but took a longer time to do so in their weaker language. This pointed to a time factor as being possibly related to the problem-solving difficulties observed in the two studies of the preceding section. However, there is no clear connection between a time factor and those difficulties, since no time limit was imposed on the children of the first two studies.

To probe deeper into the problem we had forty bilingual sixth grade boys similar to those described earlier read aloud Irish and English versions of three arithmetical problems.[6] Each boy read each version three times, and interest focussed on the improvement from first to quickest reading as much as on the absolute reading times. Though the two versions of each problem contained roughly equal numbers of words, the boys took longer to read the Irish version. Improvement from first to best time (usually third reading) was greater when reading the Irish version. The finding that reading in a weaker language takes longer than reading in a stronger confirms results obtained by other students of bilingualism.[7] The finding that reading times improve more in the weaker than in the stronger one suggests that the boys came nearer on their first reading in English than on their first reading in Irish to the speed at which they could comfortably handle semantic information.

All this leads to the conclusion that the boys experienced relatively greater difficulty in the "input process" when the language was Irish.

Analysis of reading in two languages

The remaining studies of which I would like to treat were conducted with the help of colleagues and students both in Dublin and Montreal: the detailed results are to be found elsewhere[8]. The idea behind them is that reading skill can be broken down into several measurable components. We distinguished seven such components of which the first five are clearly related to the intake of information: the perception of individual words, the perception of strings of words in grammatical sequence, the interpretation of individual words, the interpretation of syntactic structures, and the ability to anticipate the sequence of words beyond the point at which one is reading (i.e., the use of transition probabilities in written language). The remaining two components may perhaps be grouped together as being related to output (in reading aloud): articulation of individual words, and the articulation of a string of words in grammatical sequence (concatenation). Clearly the seven components are not watertight divisions; ability to anticipate because of transitional probabilities is likely to be related to ability to interpret syntactic structures. Nevertheless, we felt that it might be possible to tease them apart to some extent by means of a series of tests.

We devised for the purpose eight tests in each of two languages. With these tests we obtained eight time measures for performance in each of the two languages. The plan was to compare times across languages and in particular to study whether increases in time for successive tasks were equal in the two

languages. The eight measures were:

(i) mean perceptual thresholds for individual words;

(ii) mean perceptual thresholds for sentences;

(iii) mean reaction times to words on a screen;

(iv) mean reaction times to sentences on a screen;

(v) time taken to read text silently;

(vi) time taken to read text aloud;

(vii) time taken to read a scrambled passage silently;

(viii) time taken to read a scrambled passage aloud.

I will presently explain what is meant by these various times, but first let me say something about the materials used. Since the Montreal studies were more complete than the Dublin ones I will confine the description to the former ones. Eighteen feminine French nouns and their English equivalents were selected all naming common objects of which pictures could easily be drawn. To these were added two words in each language, a and has, so that the nouns could be combined in sentences of which half were true and half were false: e.g., a hen has a wing and a hen has a door. The words and sentences were printed on plain white cards and presented to subjects in a tachistoscope, a device like a camera which enables the experimenter to control the time of exposure. With these cards we obtained the first two measures in each language.

Two filmstrips were also prepared, one with the English words each printed beneath a picture and the other with the French words printed beneath the same set of pictures. In half the combinations the word named the picture and in half it did not. The sentences were also made into filmstrips,

one English and one French. The subjects task was to indicate whether or not the word named the picture, and whether or not the sentence was true. These tests yielded measures (iii) and (iv).

By the addition of the word and the true sentences were combined to form two different English paragraphs and two different French ones. These were printed on plain white cards and placed in subjects' hands to be read. Times taken to read these constitute measures (v) and (vi). In each language one paragraph was read silently and one aloud; in silent reading subjects indicated the words they were reading with a pointer. Finally scrambled versions of each paragraph were also typed on cards and read, two silently, two aloud. These furnished measures (vii) and (viii). Important order effects might be anticipated in the repeated testing of so small a body of material; so as far as possible the order of tests was counterbalanced across subjects. The subjects were twenty-four college girls in Montreal. All were native speakers of English, but all had taken school French throughout their time in high-school.

One other feature of the design must be explained before we proceed to the results. Since the same material was used in all eight tests there is some relationship between the different times. The relationship, however, is not a simple one because the manner in which the material was presented varied. Nevertheless, the change in manner of presentation was constant across languages. This is the central idea of the design. The absolute numbers obtained, therefore, are of less interest than the increase from one test to the next, and similarly these increases are not of such interest in themselves as their relative sizes in the two languages. The comparison of

increases across languages affords a measure of the quantities to be estimated which is all the more accurate for the fact that each subject was her own control. That is, each subject's performance in English was compared with her performance in French. Now for the results.

No significant difference was found on test (i), i.e. perception of individual words; neither was the increase from (i) to (ii) significantly greater in one language than another. Thus no significant differences were found at the perceptual level either for words or for sentences. However, the increase from (i) to (iii) was significantly larger in French than in English. This means that when times for determining the meanings of individual words were corrected for perceptual thresholds of the same words, the French times were larger than the English ones. The increase from (iii) to (iv) however was not significantly larger in one language than another.

To recapitulate the results of the first four tests, only one significant difference was found: that associated with determining the meanings of words. The absence of a significant difference at the perceptual level is less surprising when one recalls that the order of tests varied from subject to subject and that the body of language was so limited. Thus if there were a tendency for our subjects to perceive English words more rapidly than French ones it would probably have been obscured by the massed practice at reading the same words. Furthermore, French and English employ the same script. It is not surprising then that Crothers et al[9] found that English-speakers who had learned some Russian reacted more slowly to the Cyrillic characters of Russian than to English letters. The converse of the point about familiarity with the material is that where significant

differences were found in our series of tests they must have arisen from factors robust enough to withstand the effect of such familiarity.

The absence of a significant difference in association with the perception of sentences is probably attributable to familiarity also. When subjects had discovered that all sentences had the same syntax they could neglect the syntax and reduce the task to the perception of two key nouns. Remember that all sentences were of the form a hen has a wing. Similarly the absence of a significant difference associated with syntax in the fourth task could be attributed to the fact that all sentences were of the same form. All subjects had to do was fix on the two nouns and test them for a part/whole relationship. As some experiments shortly to be described will show, this interpretation is very probably the correct one.

In the analysis of times taken to read the continuous texts and scrambled passages (tests v to viii), four components were isolated. We may call these, somewhat loosely: (a) perception of individual words, (b) pronounciation of individual words, (c) use of transition probabilities, (d) concatenation (the ability to string words together when pronouncing them in sequence). These components were determined by a simple arithmetic process the key to which can be represented as follows:

task (vii)	-	scrambled passage read silently	= (a)
task (viii)	-	scrambled passage read aloud	= (a) + (b)
task (v)	-	continuous text read silently	= (a) - (c)
task (vi)	-	continuous text read aloud	= (a) + (b) - (c) - (d)

Note that (c) and (d) which contribute to a reader's speed are presented as negative quantities.

Significant differences were found only in association with (b) and (c). Subjects took longer to pronounce individual words in French, and they made less use of the transition probabilities in French. The latter finding, which replicates an earlier one described by Kellaghan and Macnamara,[10] means that in reading French sentences subjects were less able to anticipate the order of words.

The absence of a significant difference for (a), perception of individual words, replicates the finding for task (i). The absence of a significant finding for (d) means that there was no reliable difference in speed of reading attributable to differential ability to concatenate.

In order to verify our explanation of the absence of a significant difference associated with syntax in the interpretation of sentences a second experiment was carried out. This time syntax was systematically varied so that subjects would have to pay attention to it. The new sentences were of four types: active affirmative, active negative, passive affirmative, and passive negative. In composing the sentences, however, we did some violence to both English and French syntax. For example, one set might read: a hen possesses a wing; a hen does not possess a wing; a wing is possessed by a hen; a wing is not possessed by a hen. The corresponding set of French sentences would be: une poulle possède une aile; une poulle ne possède une aile; une aile est possedée par une poulle; une aile n'est pas possedée par une poulle.[11]

In all, thirty such sentences were prepared in each language, fifteen of which were true, and fifteen false. The English sentences in random order were combined in one filmstrip, the French ones in another.

The new filmstrips together with the words and pictures filmstrips (task iii) were presented to twenty-four new subjects similar to those of the first experiment, i.e. native speakers of English with a knowledge of school French. They were also presented to twenty-four native speakers of French with little more than a knowledge of school English. The reason for including the latter subjects was to find out if the main findings could be replicated in reverse with subjects whose linguistic strengths were the reverse of those of the first experiment, and also to check on the effect of tampering with the syntax, especially the French syntax.

Detailed analyses, which need not detain us here, revealed once again significant differences in the speed with which the meanings of individual words were determined. Subjects responded more rapidly in their stronger language. Further, the increase in time from the words and pictures task to the sentence task was significantly greater for the weaker language. Thus, our hypothesis was verified: subjects interpreted syntax more rapidly in their strong language.

To sum up the results of this series of experiments, significant differences between languages were found in the speed at which subjects interpreted the meaning of individual words and also the meaning of sentences, in the speed at which subjects could pronounce words, and in ability to anticipate the sequence of words in continuous prose.

Conclusion

Turn once again to the questions from which we began: is there a demonstrable difference between grasp of one language and grasp of a second one (apart from ignorance of vocabulary, idiom and syntax); and if there is, in what does the difference consist? We can now answer the first question with an affirmative. At least where the difference in grasp is as marked as it was in our subjects its effects can be demonstrated in problem solving ability and also in a series of tests designed to analyse reading skills. We must not push the conclusion too far, however. It does not follow, for instance, that similar results would be obtained with all bilinguals; after all we selected our subjects specially to reveal a marked contrast in their grasp of the two languages. Neither does it follow that bilingualism itself is the cause of anything. We have merely shown that when the contrast in grasp of two languages is sufficiently marked, the effect on certain types of problem solving and on certain aspects of reading can be demonstrated.

We have also made some progress towards answering the second question. We have found certain differences between reading in the native language and reading in a second language, - on the "input" side, in the rate at which individual words are interpreted, in the rate at which syntactic structures are interpreted, and in ability to anticipate the sequence of words; on the "output" side in the rate at which individual words are pronounced. While we cannot be sure that we have located all relative weaknesses in reading a second language, or that such weaknesses are characteristic of all persons who read a second language, we have found these weaknesses in the average reading scores of seventy-two bilinguals. We can with some confidence say, then, that when a person reads one

language more slowly than another, the factors identified are very likely to be among those which cause the slowing down.

Throughout this paper I have laid a great deal of stress on time measures. It is necessary to say a word about the value of such measures and in particular about their relevance to the whole business of reading. After all, some might counter, what does it matter if a man reads French a little more slowly than he reads English (or whatever the pair of languages may be)? It would be quite outside the scope of this paper to attempt to answer this question as it might relate to reading for pleasure or to the creative response of a person reading a literary work. In so far as an answer emerges from the evidence I have cited it must be related to reading for understanding, and here, unless I'm greatly mistaken, speed of reading has an importance of its own.

I assume that educated people generally read at a rate which enables them to digest comfortably what they read. The rate varies from person to person, and even the same person will vary his rate depending on the nature of what he reads and pressures on his time. But I assume that if he is set a written problem in a relaxed manner and without an explicit time limit, he will read it at a rate which is close to optimal for his purpose. The idea of an optimal rate comes from the fact that human nature places certain constraints on all human performance, among them the span of short-term memory. This span is not more than a few seconds and can embrace no more than about eight or nine separate units.[12] If a person is to function within these constraints and solve the problem, he has to reduce the total information

to manageable proportions and hold it firmly in that little span of awareness which we call short-term memory. If he reads too quickly he may miss some relevant points of information; if he reads too slowly and does not employ the extra time for processing the information, some relevant points may slip his mind. An optimal rate would lie somewhere between the two. Now we have seen that if a person has to read the problem in a weaker language, he must of necessity read it more slowly. What I suggest is that the slower rate in the weaker language does not allow him any added leisure for thinking about what he has read; the extra time is fully employed on the task of decoding the language. Consequently some important points may slip his mind. In fact he may have added difficulty in determining what it is that is important, since to do so presupposes some idea of the problem as a whole. As a result, the difficulty of the problem is increased and if the problem is a taxing one, even in the native language, a man is more likely to fail. I have a suspicion that the increase in difficulty of which I speak is even more upsetting for primary school children many of whom convey the impression that they give up and consider themselves lost if after one or two readings they have not discovered what the whole thing is about.

Admittedly there is a good deal of speculation involved in this reasoning, but it does tie all the findings together and it would explain why problems presented in the weaker language were more difficult to solve. Taking one thing with another it seems to me at the moment the most parsimonious way to interpret a considerable body of evidence.

FOOTNOTES

1. See J. Macnamara, Bilingualism and primary eduation, Edinburgh University Press, 1966.

2. N.T. Darcy, "A review of the literature on the effects of bilingualism upon the measurement of intelligence." Journal of Genetic Psychology, 1953, 82, 21-58.

   N.T. Darcy, "Bilingualism and the measurement of intelligence: Review of a decade of research." Journal of Genetic Psychology, 1963, 103, 259-282.

3. J. Macnamara, Bilingualism and primary education, Edinburgh University Press, 1966.

4. J. Macnamara, "The problem-solving difficulties of bilingual children." Bulletin of the British Psychological Society, 1965, 18, 58-59, (abstract).

   T. Kellaghan and J. Macnamara, "Reading in a second language. In: M.D. Jenkinson (Ed.), Reading instruction: An international forum. Newark, Delaware: International Reading Association, 1967, Pp. 231-240.

5. J. Macnamara. The use of Irish in teaching children from English-speaking homes: A survey of Irish National Schools. Unpublished Ph.D. thesis, University of Edinburgh, 1963.

6. T. Kellaghan and J. Macnamara. "Reading in a second language." In: M.D. Jenkinson (Ed.) Reading Instruction: An international forum. Newark, Delaware: International Reading association, 1967. Pp. 231-240.

7. W.E. Lambert, J. Havelka, and R.C. Gardner. "Linguistic manifestations of bilingualism." American Journal of Psychology. 1959, 72, 77-82.

P. Kolers, "Reading and talking bilingually." American Journal of Psychology, 1966, 79, 357-376

8. T. Kellaghan, and J. Macnamara, "Reading in a second language." In: M.D. Jenkinson (Ed.), Reading instruction: An international forum. Newark, Delaware: International Reading Association, 1967, Pp. 231-340.

J. Macnamara. "The effects of instruction in a weaker language." Journal of Social Issues, 1967, 23, 121-135.

J. Macnamara, M. Feltin, M. Hew, and M. Klein. "An analytic comparison of reading in two languages." Irish Journal of Education, 1968, 2, 41-53.

9. E. Crothers, P. Suppes, and R. Weir. "Latency phenomena in prolonged learning of visual representations of Russian sounds." International Review of Applied Linguistics, 1966, 2, 205-217.

10. T. Kellaghan, and J. Macnamara. "Reading in a second language." In: M.D. Jenkinson (Ed.), Reading instruction: An international forum. Newark, Delaware: International Reading Association, 1967, Pp. 231-240.

11. We were particularly worried by the violence done to French syntax. Nevertheless, as the results indicate, the sentences served our purpose well enough.

12. See G.A. Miller. "The magical number seven, plus one minus two: some limits on our capacity for processing information." Psychological Review, 1956, 63, 81-97.